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PATENT SPECIFICATION

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537,609

Application Date (in United Kingdom): Nov. 24, 1939. No. 30755/39.

Complete Specification Accepted: June 30, 1941.

COMPLETE SPECIFICATION

Improvements in and relating to Electrical Transformers

I, EDUARD FRIES, of 77, Oerlikonerstrasse, Oerlikon, Switzerland, of Swiss nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

For feeding Neon lamps, mercury vapour lamps, fluorescent lamps and the like and also for arc furnaces, for arc welding and so forth, transformers are required which provide a comparatively high idle running or ignition voltage. Since all these apparatus have the characteristics of an arc, the necessary voltage drops very rapidly to the working voltage after the ignition has been effected, the working voltage being only a small fraction of the ignition voltage.

Such transformers are therefore made with a high reactance, in order to prevent an undue rise in the current after the ignition has been effected. The energy is therefore withdrawn from the supply mains with a very low power factor which is a considerable disadvantage.

Furthermore such transformers must allow of being adjusted for different currents and more particularly in the case of arc welding transformers, a very extensive possibility of regulating the current is required, for example in the ratio 1 : 10 and more from the smallest to the greatest current values. The arc, with its so-called negative current-voltage characteristic, requires high ignition voltages for small currents, while for large currents smaller ignition voltages are sufficient. Most known constructions of transformer entirely fail to meet this important requirement.

On the other hand the Applicant has given in Specification No. 454,950 a solution, which to a large extent meets the above requirements.

The arrangement according to the present invention satisfies these requirements in a more complete manner and also makes it possible to save in constructional material as well as to increase the efficiency and power factor.

In known transformers the iron member is usually so constructed that the magnetic flux produced by the primary winding has two parallel paths available, over which the magnetic flux is differently distributed according to whether the transformer is running idle or is loaded. These two parallel paths themselves form a closed magnetic shunt circuit.

The invention consists in a transformer with a high regulable reactance, in which at least two parallel paths are available for the magnetic flux produced by the primary winding, such paths being formed preferably by two core limbs forming a magnetic shunt circuit, characterised by the feature that this magnetic shunt contains a regulable air gap and around it at least one secondary winding the voltage of which is applied to a consuming device with approximately capacitive current consumption, so that the ampere turns thereby formed in the secondary winding are approximately in phase with the primary magnetisation current and produce in the magnetic shunt circuit an additional superposed magnetic flux which grows with diminishing the regulable air gap and *vice versa* and whereby since the secondary winding lies partly on the magnetic shunt circuit, the idle running voltage induced therein is correspondingly increased.

The invention is illustrated by way of example in the accompanying drawings, in which:

Figure 1, shows one construction,

Figure 2 is an alternative construction

Figure 3 being a modification of a detail of the construction as generally shown in Figure 2, while

Figure 4 illustrates a further construction, and

Figure 5 illustrates a circuit embodying a transformer in accordance with the invention,

In Figures 1 and 2, 9 is the main core with the corresponding primary winding 10, the magnetic flux produced by the latter being indicated by arrows and being divided between the limbs 11 and 12. 13 is the secondary winding and 14 the auxiliary winding with the capacitative current-consuming device connected thereto. In order to adjust the secondary cur-

rent to the desired value, at least one regulable air gap 16 is provided in the magnetic shunt circuit. The adjustment is effected by moving the limb 12 or the leakage core 17.

In most of the hitherto known transformers which have been constructed similarly to those shewn in Figs. 1 and 2 but without the auxiliary winding 14 on the magnetic shunt circuit and the capacitative current-consuming device 15 as proposed by the Applicant, the following important drawbacks are found. Of the magnetic flux produced by the primary winding 10, a part does not flow through the secondary winding 13 so that there is a loss in induced secondary voltage, which may be considerable especially with small air gaps 16. The air gap 16 should therefore not be reduced below a certain minimum in order to keep the loss of secondary idle running voltage within reasonable limits. In this way, however, the possibility of regulating the current from the smallest up to the greatest air gap is greatly restricted. By means of the present invention this very detrimental loss in secondary idle running voltage can be avoided and also the desired increase in this voltage can be obtained. This increase is greater, the smaller is the magnetic resistance of the shunt circuit, that is the smaller are the air gaps 16. These latter can therefore be reduced to zero whereby a very great range of regulation of the current can be obtained. It is important, more particularly for arc welding, that high idle running or ignition voltages should be obtained for small currents, and diminishing ignition voltages for increasing currents, since small currents are obtained for small air gaps and *vice versa*. In this way the correct association of currents and ignition voltages for the conditions of the electrical arc are obtained.

The invention includes also a construction differing from that in Figs. 1 and 2, which was proposed by the Applicant according to Patent No. 454,950 and Patent of Addition Application No. 20643/39 and of which Fig. 4 shews a constructional example. In Fig. 4 18 is the primary and 19 the secondary winding. 20 is a choke or secondary auxiliary winding which is arranged around the variable air gap 21. The magnetic flux generated in the core part 22 by the primary winding 18 again has two parallel paths available, as indicated by arrows, one of which leads through the air gap 21 and the movable core part 23, while the other leads through the unwound yoke 24.

This arrangement, as is stated in the above-mentioned specifications, already gives to a large extent the advantages which are obtained by the present invention. It has the correct association of currents and ignition voltages in accordance with the arc conditions. Further, the regulable air gap can be reduced to zero, since thereby a very great increase in the secondary idle running voltage and an extremely great range of regulation of the current can be obtained by varying the air gap 21.

In spite of this the present invention has advantages also for this construction. According to this invention a further auxiliary winding 25 is provided to which likewise a capacitative current-consuming device 26 is connected. Here also the elements 25 and 26 produce an additional excitation in the magnetic shunt circuit 23, 21, 24. By means of them the voltage induced in the winding 20, which is added to the voltage generated in the secondary winding 19, is increased. This results in a higher secondary resultant idle running voltage which is greater, the smaller is the air gap 21 and the smaller is the secondary working current. The advantages obtained with Patent No. 454,950 are obtained to a still greater extent with the present invention.

As the air gaps 16 and 21 become larger, a constantly increasing resistance is offered in the magnetic shunt circuit formed by the two limbs 11 and 12 or 23 and 24 to the magnetic flux additionally produced therein. In order always to have an additional secondary voltage increase to the desired extent, even with maximum air gap, the air gap 16 or 21 may be wholly or partly bridged over by a magnetic conductor of small cross-section.

Fig. 3 shews how such a bridging over may be effected for example for the construction according to Fig. 2. The same reference numerals are used as in Fig. 2 and the magnetic bridge 27 is also shewn. This should have only a small cross-section in comparison with the magnetic flux passing through the air gap 16, so that the possibility of regulating the working current by the variation of the air gap 16 is not unduly reduced.

Instead of the separate auxiliary windings 6, 14 or 25 for feeding the capacitative current-consuming device, it is also possible to use the secondary winding or parts thereof for this purpose.

On the main core 2 or 9 and 22, the primary winding may also be provided in an auto transformer arrangement and the primary voltage may as required be transformed to a higher or lower voltage and

then connected in series with the secondary winding of the magnetic shunt circuit. This circuit is shewn in Fig. 5. In this Figure, 28 is the auto transformer arrangement, 29 is the secondary winding on the magnetic shunt circuit and 30 is the capacitative current-consuming device and 31 the apparatus to be supplied, for example a gas discharge lamp.

As capacitative current-consuming device, for the sake of simplicity, one or more condensers may be used. It is, however, also possible without in any way altering the essence of the invention to obtain the necessary advance phase current, for example, by means of a small over-excited synchronous motor instead of the condenser. This motor may be fitted with a fan and used at the same time for cooling the windings or any condensers or dry rectifiers which may be provided.

In the constructional examples described, single phase transformers have been referred to for the sake of simplicity. Exactly the same principle, however, can be applied to multiphase transformers also. These are used for example usually in three-phase construction for feeding rectifiers for continuous current arc welding.

Such a three-phase construction can be obtained, for example, with similar constructional elements to those used for the single phase construction by inserting a further limb in Figures 2 and 4. The movable part of the magnetic core of the choke coil in Fig. 4 would then no longer be **U**-shaped but **E**-shaped.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A transformer with a high regulable reactance, in which at least two parallel paths are available for the magnetic flux produced by the primary winding, such paths being formed preferably by two core limbs forming a magnetic shunt circuit, characterised by the feature that this magnetic shunt contains a regulable air gap and around it at least one secondary winding the voltage of which is applied to a consuming device with approximately capacitative current consumption, so that the ampere turns thereby formed in the secondary winding are approximately in phase with the primary magnetisation current and produce in the magnetic shunt circuit an additional superposed magnetic flux which grows with diminishing the regulable air gap and *vice versa* and whereby since the secondary winding lies partly on the magnetic shunt circuit, the idle running voltage induced therein is correspondingly increased.

2. A transformer as claimed in Claim 1, characterised by the feature that the secondary winding carrying the capacitative current is in the form of a separate auxiliary winding provided for this purpose only, there being complete freedom as to the choice of the voltage of this winding.

3. A transformer as claimed in Claim 1, characterised by the feature that the capacitative secondary current consuming device is connected to the secondary working winding and there is no secondary auxiliary winding provided for this purpose.

4. A transformer as clamed in Claim 1 to 3, characterised by the feature that the capacitative current is obtained by means of at least one condenser of any suitable construction.

5. A transformer as claimed in Claim 1 to 3, characterised by the feature that the capacitative current is obtained by means of an over-excited synchronous motor which may serve at the same time for other purposes as for example running a fan for cooling purposes.

6. A transformer as claimed in Claim 1 to 5, characterised by the feature that in order to adjust the working current at least one air gap is provided which is permanently bridged over by at least one magnetic conductor which is only capable of taking up a fraction of magnetic flux flowing through the air gap.

7. A transformer as claimed in Claim 1 to 6, characterised by the feature that the primary voltage is first transformed to a suitable intermediate voltage in an auto transformer arrangement and with the intermediate voltage the secondary winding proper on the magnetic shunt circuit is connected in series.

8. The improved high reactance transformer substantially as hereinbefore described with reference to the accompanying drawing.

Dated this 8th day of November, 1939.

MARKS & CLERK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1941.

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

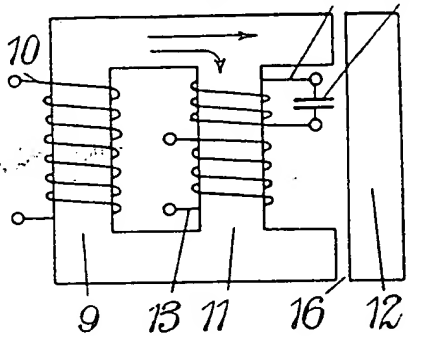


Fig. 2.

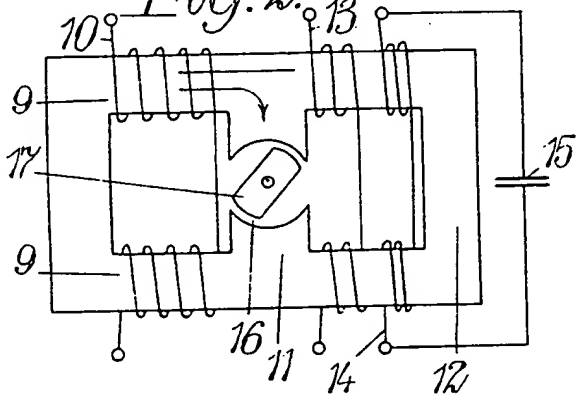


Fig. 3.

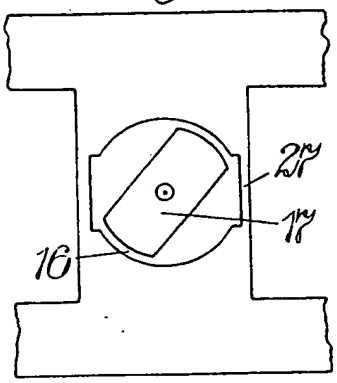


Fig. 4.

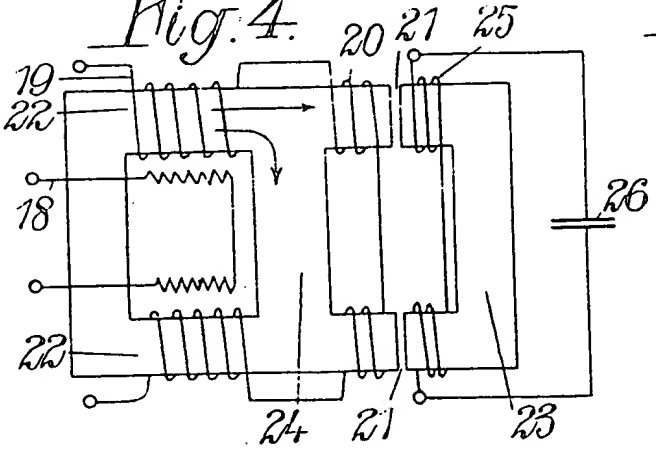
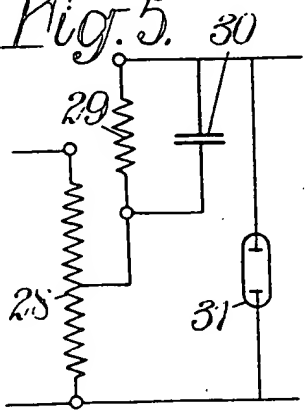


Fig. 5.



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